FMCW Radar

For a triangular frequency modulation and using these symbols

Δf	Peak to peak frequency deviation
c	Speed of light (300 million m/s)
f_m	Modulation frequency of the triangular wave
R	Range (distance) to the target (m)

The time delay between the transmitted signal and the received echo is:

$$T = \frac{2R}{c} \qquad (1)$$

When the transmitted signal is mixed with the echo, the beat frequency is:

$$f_b = \frac{4\Delta f \cdot f_m \cdot R}{c} \qquad (2)$$

This is shown for two targets at 15km and 50km in the figures below.

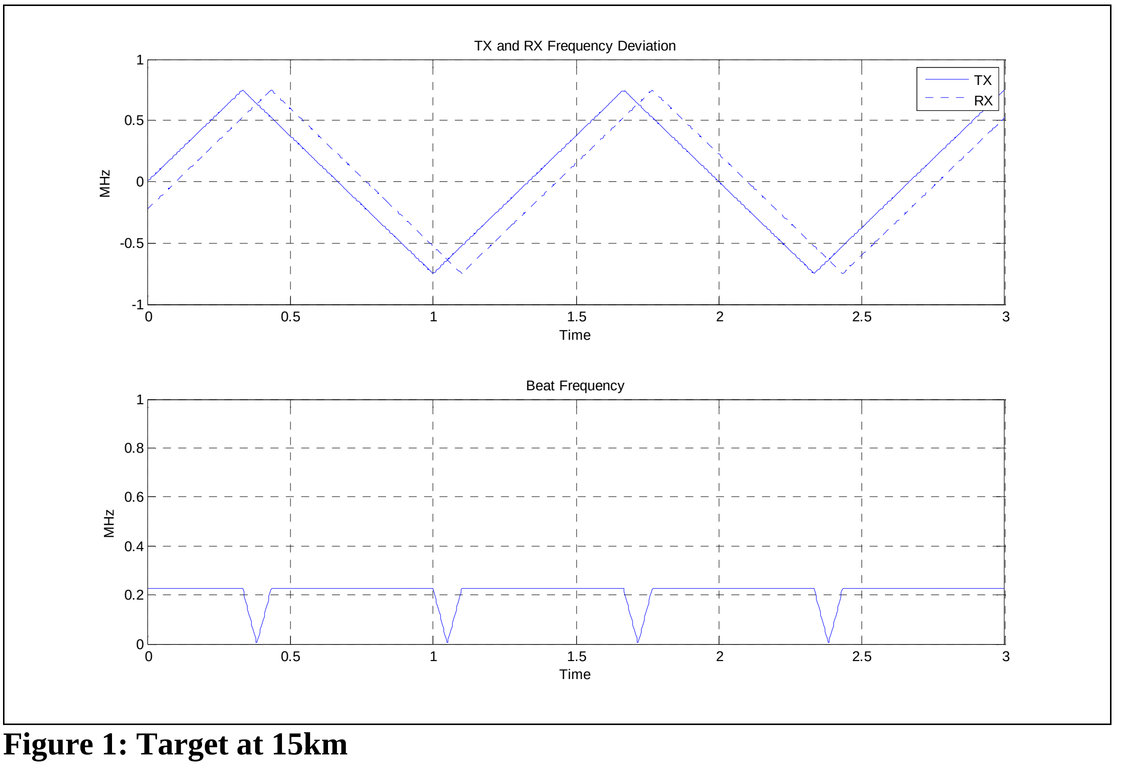

Figure 1: Target at 15km

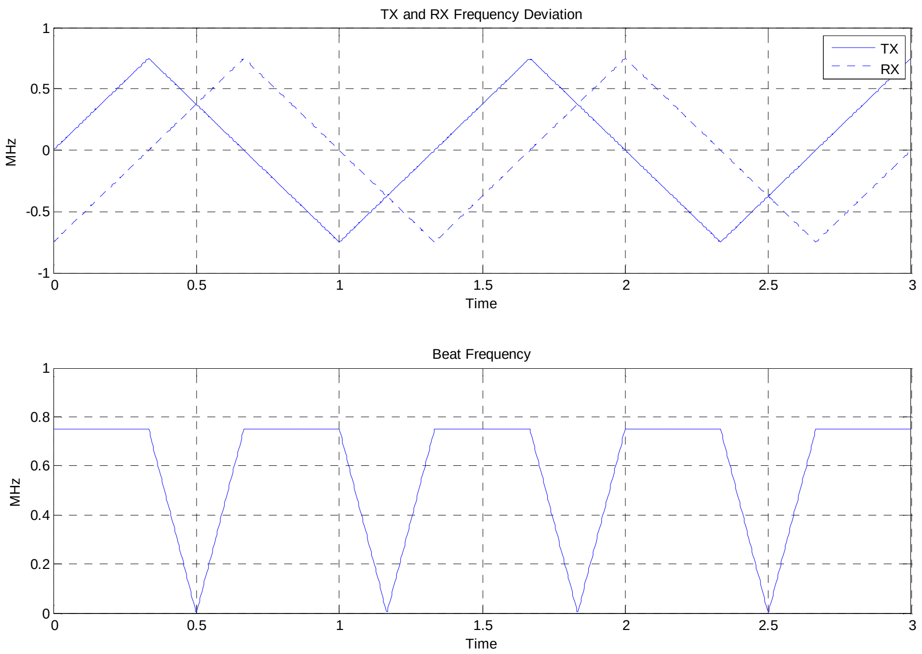

Figure 2: Target at 50km

The time where the beat frequency is constant and where it can be measured without error becomes less and less as the range increase. If you want to keep a constant time for frequency measurement (e.g. with an FFT of fixed duration), then you may make a choice and limit the maximum range of the target.

If you make a choice to use 50% of the cycle for frequency measurement (the second half of the up-sweep and down-sweep corresponding to the flat tops in Figure 2) then that limits the maximum range delay to half of the up-sweep, which is equivalent to a quarter of the sweep period.

$$R_{MAX} = \frac{c}{8 f_m} \qquad (3)$$

The time for making a frequency measurement is limited to

$$t_b = T_{MAX} = \frac{1}{4 f_m} \qquad (4)$$

That limits the resolution of the frequency measurement to $4f_m$ and the corresponding range resolution is

$$\Delta R = \frac{c}{\Delta f} \qquad (5)$$

Equation2 (3) and (5) are the basis of the FMCW radar. For a resolution of 200 m and a maximum range of 50 km they result in Δf = 1.5 MHz and f_m = 750 Hz.